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W. Carl Lineberger and Stephen R. Leone

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This final report describes the equipment purchased on the project and modifications to the items obtained. The equipment is being used in the study of energetic doubly-charged molecular ion species.

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22a. NAME OF RESPONSIBLE INDIVIDUAL
Dr. Francis J. Wodarczyk

22b. TELEPHONE (Include Area Code)
(202) 767-4963

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DURIP Final Report

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(1) A titanium sapphire laser has been procured instead of the ring dye laser. The availability of this fundamentally new kind of laser technology, which spans the region of the infrared dyes, allows us to achieve substantially more power with the same required tunability of the originally specified dye laser.

(2) The pulsed dye laser and nonlinear crystals were purchased totally with AFOSR funds, and the position sensitive detector is being obtained on University of Colorado matching funds. No changes are being made to the overall set of requested equipment or the goals of the research.

The acquisitions on AFOSR funds were:

Quanta Ray, DCR-4, Pulsed Nd:YAG Laser, PDL-3 Pulsed Dye Laser and HG-2 Nonlinear Frequency Module for YAG Laser	$ 85,467.50
Quanta Ray Beam Combinears and Nonlinear Doubling Crystals BC-2,3, C2,3 for Dye Laser	$ 3,950.00
Barium Borate crystal (only partial on AFOSR funds, the rest on University matching)	$ 703.00
Schwarz Electro-optics, Titanium Sapphire Laser, Titan-cw (the rest on University matching)	$ 25,030.00

The titanium sapphire laser has been modified with a thick etalon to achieve single frequency scanning capability. The Nd:YAG laser and dye laser have been modified with a home-built scanning system. Below is a brief report of the status of the projects.

Considerable progress has been made in the experimental program of Lineberger, Szaflarski and Mullin. Preliminary investigations using our medium pressure electrical discharge ion source gave reasonable quantities of NO^{++} and several other dications. Of particular relevance was the fact that these ions survived the rather severe collisional environment of the ion source. The nature of this source, however, did not permit very controlled formation conditions. Consequently, the ion source has been replaced with an electron impact ionized supersonic expansion source. Construction of this source has been completed, and the first mass spectra of dications have just been obtained.

Prior to obtaining photodissociation spectra of dications, we have been required to make several significant modifications to the detection system in our coaxial beam machine, and significant improvements in the tunable laser dissociation light source. We have completed the design of a detection scheme which will allow coincident detection of both ionic photofragments, and construction of the last pieces is underway in the mechanical shop. Assembly should be completed by the beginning of 1990. The first system to be studied, NO^{++}, has its most favorable absorption band in the near-infrared, the spectral region which will be covered by our new Ti:sapphire laser. A single frequency Ti:sapphire

commercial laser was delivered in September but, as we had known, this laser was not continuously tunable. Taking advantage of the considerable expertise in single frequency tunable lasers, both in our group and in other research groups in JILA, we have successfully modified this commercial laser to make it continuously tunable over a several cm^{-1} spectral region with high (700 mW) power. A brief description of these results will be prepared for publication in the near future, and the results will be made available to the company for possible incorporation in their commercial device.

Thus, all of the components required to study photodissociation of dications are either completed or in the shops at the moment. We expect first results on NO^{++} in the near future.

In the experimental work of Leone, a new ion source has been devised to optimize the production of doubly-charged molecular cations. This source consists of an electron impact ionizer which is crossed with a pulsed jet of neutral precursor molecules in a differentially pumped chamber. The ions are immediately extracted and passed through a quadrupole mass spectrometer and then detected with an electron multiplier in a large analysis chamber. The flight time in the mass selector for a typical doubly-charged ion is about 10 μs, thus molecular ıtion species with lifetimes longer than 10 μs are readily observed. With this source, a wide array of well-known and new doubly-charged molecular ions have been formed. The doubly-charged ions are confirmed by their unique half-mass values in the quadrupole mass selector. An essential point is that this source is already delivering

useful quantities of mass-selected dications for studies in subsequent collision experiments.

Using the NF_3 precursor, the species NF_2^{++} and NF^{++} are observed; the latter species is the subject of a recent theoretical investigation by the group of Radom, and our observation is the first reported confirmation of the stability of this dication. The appearance potential of NF^{++} from NF_3 is measured to be 43.8 eV. This work has recently been submitted for publication in *Chemical Physics Letters*.

With HCl and DCl precursors, both HCl^{++} and DCl^{++} species are observed. Using CCl_4, a wide variety of species are formed, including CCl^{++}, $HCCl^{++}$, and H_2CCl^{++}, several of which may be previously unreported. With CF_4, we observe CF^{++}, CF_2^{++} and CF_3^{++}. We also observe the readily made species, NO^{++} and CO^{++}, starting from their parent neutrals.

We are presently working on an eight-photon double ionization process in NO and a ten-photon process for N_2 (to produce NO^{++} and N_2^{++}, respectively). Imaging of the lasers into the requisite beam volume and various single ionization experiments have been successful. The next step is to excite the singly-charged ions electronically and then to carry out the second ionization. The pulsed laser system is used almost daily in these attempts. The laser system will also be used to carry out photo-fragmentation experiments on the dications that have been produced by the electron impact source.